Hadronic B decays at BELLE and BABAR

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There are several exciting results for the hadronic B decays of Belle and BaBar recently. My report focuses on the ratios of branching fractions and CP asymmetry for $B \to hh$ decays at Belle and BaBar where h denotes π or K. The observations of $B^+ \to K^+\overline{K}^0$, $B^0 \to K^0\overline{K}^0$ are published both by Belle and BaBar and shown here. We also report the observation of $B^+ \to \rho^+ K^0$ and search of $B^+ \to \overline{K}^{*0}K^+$, $B^0 \to \rho^0\rho^0$, $B^0 \to a_0^-\pi^+$ and $B^0 \to a_0^- K^+$ at BaBar. Finally, we will show the results of amplitude analysis of the decays $B^0 \to \phi K_2^*(1430)^0$, $\phi K^*(892)^0$ and $\phi(K\pi)^0_{\mathrm{S-wave}}$ at BaBar.

1 Introduction

In general, the branching fractions with the SM predictions suffer from large hadronic uncertainties within the current theoretical framework and many of the uncertainties cancel out in ratios of branching fractions. We report the ratios $R_{c,n}$ of the charged and neutral $B \to K\pi$ branching fractions and direct CP asymmetry of $B \to K\pi$. Theoretical predictions with different approaches suggest that $A_{CP}(K^+\pi^-)$ could be either positive or negative [1]. Although there are large uncertainties related to hadronic effects in the theoretical predictions, results for $A_{CP}(K^+\pi^-)$ and $A_{CP}(K^+\pi^0)$ are expected to have the same sign and be comparable in magnitude [1]. The observation of $B^0 \to K^0\overline{K}^0$ and $B^+ \to \overline{K}^0 K^+$ expected to be dominated by the loop-induced $b \to d\overline{s}s$ process (called a $b \to d$ penguins) are published by Belle and BaBar recently. BaBar also observed $B^+ \to \rho^+ K^0$ decay which is expected to be a pure penguin decays and the result helps to separate the contribution of tree and penguin amplitudes in other channels. For the amplitude analysis, we will show the results of $B^0 \to \rho^0\rho^0$ and $B^0 \to \phi K_2^*(1430)^0$, $\phi K^*(892)^0$ and $\phi(K\pi)^0_{S-\mathrm{wave}}$. The nature of the a_0 meson is still not well understand and the branching fractions of $B^0 \to a_0^-\pi^+$, $B^0 \to a_0^- K^+$, $B^0 \to a_0(1450)^-\pi^+$ and $B^0 \to a_0(1450)^- K^+$ will provide some information about the nature of a_0.

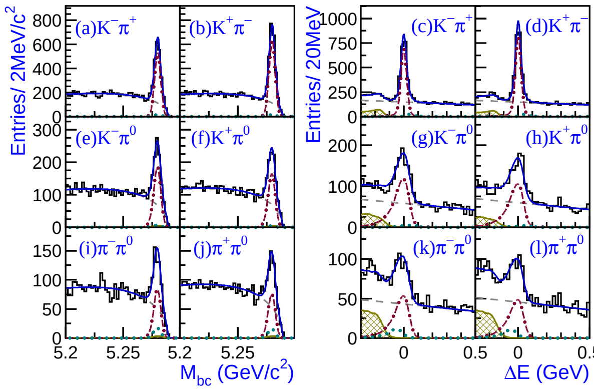

Figure 1: $M_{\rm bc}$ (left) and ΔE (right) distributions for $B^0 \to K^+\pi^-$, $B^+ \to K^+\pi^0$ and $B^+ \to \pi^+\pi^0$ candidates at Belle. The histograms show the data, while the curves represent the various components from the fit: signal (dot-dashed), continuum (dashed), charmless B decays (hatched), background from mis-identification (dotted), and sum of all components (solid). The $M_{\rm bc}$ and ΔE projections of the fits are for events that have $|\Delta E| < 0.06$ GeV (left) and 5.271 GeV/c^2 $< M_{\rm bc} <$ 5.289 GeV/c^2 (right). (A looser requirement, -0.14 GeV $< \Delta E < 0.06$ GeV, is used for the modes with a π^0 meson in the final state.)

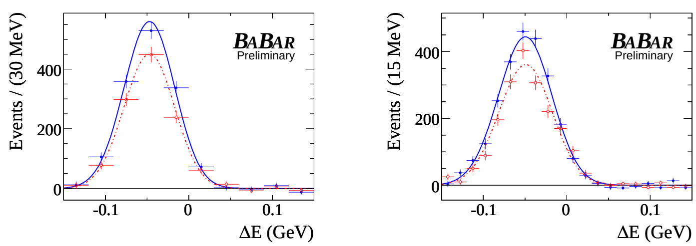

Figure 2: The background-subtracted distribution of ΔE for signal $K^\pm\pi^\mp$ events with data sample 347 M $B\overline{B}(left)$ and 383 M $B\overline{B}$ (right) at BaBar, comparing B^0 (solid) and $\overline{B}^0$ decays (dashed).

2 $B \to K\pi$, $\pi\pi$ and KK

The new measurements of the branching fractions for $B \to K^+\pi^-$, $K^+\pi^0$, $K^0\pi^0$, $\pi^+\pi^-$ and $\pi^+\pi^0$ at Belle [2] and BaBar [3,4] are shown in Table 1. The effect of final-state radiation is considered in branching fraction measurement now. The statistical errors on the branching fraction for all decay modes are reduced. The ratio R_c (R_n) obtained by Belle and BaBar's experimental results are $1.08 \pm 0.06 \pm 0.08$ ($1.08 \pm 0.08^{+0.09}_{-0.08}$) and 1.11 ± 0.07 (0.94 ± 0.07), respectively. The current R_c and R_n haved moved quite a bit towards the SM predictions and reduce the "$B \to K\pi$ puzzle". The observation of $B^0 \to \overline{K}^0 K^0$ and $B^+ \to \overline{K}^0 K^+$ by Belle [5] and BaBar [6] are shown in Table 1 and the results agree with some theoretical predictions [7,8,9,10,11].

Throughout this letter, the partial-rate asymmetry is define as $A_{CP}(B \to f) = (\Gamma(\overline{B} \to \overline{f}) - \Gamma(B \to f))/(\Gamma(\overline{B} \to \overline{f}) + \Gamma(B \to f))$, where $\overline{B}$ and $\overline{f}$ are the conjugate states. Belle provides the partial-rate asymmetries for $B^0 \to K^+\pi^-$, $B^+ \to K^+\pi^0$ and $B^+ \to \pi^+\pi^0$ three decay modes and the results are shown in Fig. 1 and Table 2. The partial-rate asymmetry $A_{CP}(K^+\pi^-)$ is found to be $-0.093 \pm 0.018 \pm 0.008$, which 4.8σ from zero. The measurement of $A_{CP}(K^+\pi^0)$ is consistent with no asymmetry; the central value is 4.4σ away from $A_{CP}(K^+\pi^-)$. BaBar also provides the partial-rate asymmetry for these three decay modes shown in Fig. 2 and Table 2 and claims the observation of the partial-rate asymmetry $-0.107 \pm 0.018^{+0.007}_{-0.004}$ with 5.5σ [12].

Table 1: Summary of branching fractions

	Belle		BaBar	
Mode	N_{signal}	BF(10^{-6})	N_{signal}	BF(10^{-6})
$K^+\pi^-$	3585^{+69}_{-68}	$19.9 \pm 0.4 \pm 0.8$	1660 ± 52	$19.7 \pm 0.6 \pm 0.6$
$\pi^+\pi^-$	$872\ ^{+41}_{-40}$	$5.1 \pm 0.2 \pm 0.2$	489 ± 35	$5.8 \pm 0.4 \pm 0.3$
K^+K^-	$2.5\ ^{+5.0}_{-3.7}$	< 0.41	3 ± 13	< 0.4
$K^+\pi^0$	1493^{+57}_{-55}	$12.4 \pm 0.5 \pm 0.6$	1239 ± 52	$13.3 \pm 0.6 \pm 0.6$
$\pi^+\pi^0$	693^{+46}_{-43}	$6.5 \pm 0.4\ ^{+0.4}_{-0.5}$	572 ± 53	$5.1 \pm 0.5 \pm 0.3$
$\overline{K}^0K^+$	$36.6\ ^{+9.7}_{-8.3}$	$1.22\ ^{+0.32+0.13}_{-0.28-0.16}$	71 ± 19	$1.61 \pm 0.44 \pm 0.09$
$K^0\pi^+$	$1252\ ^{+41}_{-39}$	$22.8^{+0.8}_{-0.7} \pm 1.3$	1072 ± 46	$23.9 \pm 1.1 \pm 1.0$
$K^0\overline{K}^0$	$23.0\ ^{+6.5}_{-5.4}$	$0.87^{+0.25}_{-0.20} \pm 0.09$	32 ± 8	$1.08 \pm 0.28 \pm 0.11$
$K^0\pi^0$	379^{+28}_{-27}	$9.2 \pm 0.7\ ^{+0.6}_{-0.7}$	425 ± 28	$10.5 \pm 0.7 \pm 0.5$
ρ^+K^0	-	-	158^{+27}_{-26}	$8.0^{+1.4}_{-1.3} \pm 0.5$

Table 2: Summary of partial-rate asymmetry

	Belle(535M $B\overline{B}$)	BaBar(347M $B\overline{B}$)	BaBar(383M $B\overline{B}$)
Mode	A_{CP}	A_{CP}	A_{CP}
$K^+\pi^-$	$-0.093 \pm 0.018 \pm 0.008$	$-0.108 \pm 0.024 \pm 0.007$	$-0.107 \pm 0.018^{+0.007}_{-0.004}$
$K^+\pi^0$	$0.07 \pm 0.03 \pm 0.01$	$0.016 \pm 0.041 \pm 0.010$	-
$\pi^+\pi^0$	$0.07 \pm 0.06 \pm 0.01$	$-0.019 \pm 0.088 \pm 0.014$	-

3 $B^+ \to \rho^+K^0$, $B^0 \to \rho^0\rho^0$ and $B^0 \to \phi K^{*0}$

The pure penguin $b \to s$ decay process $B^+ \to \rho^+K^0$ is observed by BaBar recently [14]. The measured branching fraction is $(8.0^{+1.4}_{-1.3} \pm 0.5) \times 10^{-6}$ shown in Table 1 with 7.9σ significance and is consistent with theoretical prediction with the assumption $p'_V = -p'_P$ [13] within the uncertainties. The p'_V (p'_P) is the amplitude for the spectator quark to appear in the vector (pseudoscalar) meson.

The value of $\Delta\alpha$ can be extracted from an analysis of the branching fractions of the B decays into the full set of isospin-related channels [15]. BaBar finds the evidence for $B^0 \to \rho^0\rho^0$ with 3.5σ significance and measures the branching fraction $(1.07 \pm 0.33 \pm 0.19) \times 10^{-6}$ [16]. With the $B^0 \to \rho^0\rho^0$ measurement, BaBar obtains a 68% (90%) CL limit on $|\Delta\alpha| \equiv |\alpha - \alpha_{\rm eff}| < 18^o$ ($< 20^o$). An isospin-triangle relation holds for each of the three helicity amplitudes, which can be separated through an angular analysis. The longitudinal polarization fraction $f_L = |A_0|^2/(\sum |A_\lambda|^2)$ of $\rho^0\rho^0$ is $0.87 \pm 0.13 \pm 0.04$, where $A_{\lambda=-1,0,+1}$ are the helicity amplitudes.

The large fraction of tranverse polarization in the $B \to \phi K^*(892)$ decay measured by Belle [17] and BaBar [18] indicates a significant departure from the naive expectation of dominant longitudinal polarization. BaBar extend their investigation of the polarization puzzle with an amplitude analysis of the vector-tensor $B^0 \to \phi K_2^*(1430)^0$ decay and vector-scalar $B^0 \to \phi(K\pi)_0^{*0}$ decay [19]. The amplitudes are reparameterized with the index J suppressed as A_0 and $A_{\pm1} = (A_\parallel \pm A_\perp)/\sqrt{2}$ and the transverse polarization fraction is defined as $f_\perp = |A_\perp|^2/\sum |A_\lambda|^2$. The polarization results are

$$f_L(B^0 \to \phi K^*(892)^0) = 0.506 \pm 0.040 \pm 0.015$$
$$f_L(B^0 \to \phi K_2^*(1430)^0) = 0.853^{+0.061}_{-0.069} \pm 0.036$$
$$f_\perp(B^0 \to \phi K^*(892)^0) = 0.227 \pm 0.038 \pm 0.013$$

$$f_{\perp}(B^0 \to \phi K_2^*(1430)^0) = 0.045^{+0.049}_{-0.040} \pm 0.013$$

4 $B \to a_0 K$ and $a_0 \pi$

BaBar apply separate fits to determine the $a_0(980)$ and $a_0(1450)$ yields since this results in $\sim$20% better sensitivity for $a_0(980)$. The $a_0(1450)$ fit has a component for $a_0(980)$ with the yiled fixed to the value found in the $a_0(980)$ fit, corrected for the small efficiency difference. Since the branching fraction for $a_0 \to \eta\pi$ is not well known, the following is the 90% C.L. upper limits of product branching fraction [20]. Since the branching fractions of these decays are similar, it means the $a_0(980)$ meson tend to four-quark state [21].

$$\mathcal{B}(B^0 \to a_0^- \pi^+) \times (a_0 \to \eta\pi) < 3.1 \times 10^{-6}$$
$$\mathcal{B}(B^0 \to a_0^- K^+) \times (a_0 \to \eta\pi) < 1.9 \times 10^{-6}$$
$$\mathcal{B}(B^0 \to a_0(1450)^- \pi^+) \times (a_0 \to \eta\pi) < 2.3 \times 10^{-6}$$
$$\mathcal{B}(B^0 \to a_0(1450)^- K^+) \times (a_0 \to \eta\pi) < 3.1 \times 10^{-6}$$

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